

REMARKS

Claims 1 and 6-19 were previously pending. Claim 13 has been cancelled. Claim 1 has been amended to recite a composite porous film “wherein a polyamide-imide resin porous film and a polyolefin porous film are combined.” Claims 10-12, 14, 18, and 19 have been amended to recite the composite porous film. Support for the amendments can be found at least in page 10, line 24 to page 11, line 21. No new matter has been introduced. Upon entry of this amendment, claims 1, 6-12, and 14-19 will be pending.

Claim Rejections -- 35 U.S.C. 103

I. Rejections of claims 1, 9-12, 18, and 19 under 35 U.S.C. 103(a)

Applicants respectfully traverse the obviousness rejections of claims 1, 9-12, 18, and 19 over Toyobo (JP 07100201), with evidentiary support from Deshpande et al. (US 2003/0215644).

Claim 9 has been amended to recite “a composite porous film having a thickness of 5 to 100 μm , wherein a polyamide-imide resin porous film and a polyolefin porous film are combined, and the polyamide-imide resin porous film comprises a porous layer of a polyamide-imide resin having a glass transition temperature of 70°C or higher, an inherent viscosity of 0.5 dl/g or higher and an amide bond/imide bond ratio of from 10/90 to 45/55.” As explained below, the claimed composite porous film has significantly superior properties.

(A) Excellent Affinity For Electrolyte as Composite Porous Film as a Whole.

The present composite porous film that includes a polyamide-imide resin (PAI) porous film has a better affinity for electrolyte than polyolefin porous film (e.g., polyethylene (PE) porous film) alone. This is because (i) it has a better affinity for electrolyte as a resin and (ii) the PAI resin porous film and the PE porous film have pores for communication that are structurally different.

The PAI resin porous film employed in the present invention has a three dimensional network structure allowing electrolyte to freely move in both the in-plane and the thickness directions. Reference figure 1 attached hereto (corresponding to Fig. 2 of JP 2007-125821) shows a PAI resin porous film having three dimensional pores for communication. From this figure, one can see that the PAI resin porous film allows electrolyte to freely move in both directions parallel and perpendicular to its plane.

The specification discloses that such structure can be implemented, for example, by producing the PAI resin porous film by extruding PAI resin in the form of a film and subsequently introducing it into a solution that is miscible with a solvent dissolving the PAI resin and is a poor solvent for the PAI resin to coagulate the polyamide-imide resin (page 8, lines 17-27). Applicants Note that a large number of reports have been filed since 1990s indicating utilizing a poor solvent to make a film more porous to enhanced the performance of the film.

In contrast, a polyolefin porous film (e.g., PE porous film) is used as a separator for a lithium ion secondary battery (LIB). Industrially it is usually produced by a phase separation method indicated in the attached Reference Fig. 2 (obtained from "Shaping a Separator for Ion Secondary Battery," Seikei Kakou Vol. 11, 1999, Hiroshi TANJI, the Japan Society of Polymer Processing, page 762, Fig. 2, Method of Producing a Separator for LIB and its Microstructure). This phase separation method essentially requires a drawing step after phase separation. Cracks caused at an interface of a sea-island structure caused by phase separation are enlarged by drawing to form pores for communication that are connected in a direction perpendicular to the plane. The PE porous film thus obtains necessary pores by drawing in the direction of the plane, and is thus hardly expected to have formed therein pores connected in the direction of the plane. Consequently, the film hardly allows electrolyte to move laterally.

In summary, the present invention employs a PAI resin porous film that has a better affinity for electrolyte as resin than PE does, and also has pores for

communication structurally different than PE. This allows a battery to be produced with electrolyte absorbed at an increased rate and thus introduced in a reduced period of time to achieve a shorter process. Furthermore, the PAI resin porous film employed in the present invention has a three dimensional network structure allowing electrolyte to move laterally. This can reduce liquid shortage caused locally at a surface of an electrode and thus provide a battery with a longer life. In particular, an improved charging/discharging characteristic can be provided near the end of the battery life.

Furthermore, a PAI resin porous film has a better affinity for electrolyte than a polyolefin porous film (e.g. a PE porous film) alone. Stacking these films together provides a porous film having an improved affinity for electrolyte as a whole. A battery using the porous film so produced as a separator can exhibit improved performance.

In addition, the claimed film has a larger modulus of elasticity compared with a polyolefin porous film alone. Because it is less likely to collapse due to the pressure exerted during the winding process, the claimed film can maintain its communication pores' spatial volume. This allows electrolyte to be better held.

(B) Excellent Balance between Shutdown (SD) Property and Meltdown (MD) Property and Less Peelability in Layered Structure

The present composite porous film includes a PAI having a molecular weight with an inherent viscosity of 0.5 dl/g or higher. When a solution of such PAI is applied to a polyolefin porous film (e.g., PE porous film), to produce a layered porous film, the relatively high viscosity helps prevent the PAI from penetrating the PE porous film. Penetration of the PE porous film may lead to poor SD and MD properties. When PAI penetrates a PE film, the PE porous film will contain a portion formed of a PAI component that does not deform at the SD temperature. This prevents the softened PE from flowing. Consequently, the SD temperature rises and disappears, resulting in an impaired SD property. In addition, penetration of PAI into a PE film causes the

closure of the pores, which contributes to poor gas permeability and poor characteristics of a battery, such as increased internal resistance and a reduced cycle life.

The present invention that employs a PAI having a particular molecular weight or larger allows production without the PAI penetrating a film, and can thus provide a composite porous film presenting an excellent balance between SD and MD properties.

Furthermore, the PAI having a sufficient molecular weight as described above allows a PAI resin porous film and a polyolefin porous film to be stacked together to provide a layered structure without the PAI resin porous film cracking or coming off during production. Furthermore, the PAI having the sufficient molecular weight can be maintained at the MD as a film of PAI without cracking; the PE can thus be prevented from flowing and contracting.

(C) PAI, having great strength as resin, can maintain strength in comparison with polyolefin porous film alone even when a film reduced in thickness is formed.

In the present invention, breakage, pinholes and other problems that have conventionally been caused when a thin polyolefin porous film is alone used can be reduced by stacking a PAI that has great strength as resin. While generally a film unduly reduced in thickness would invite shortage of electrolyte, reducing the thickness of the claimed film does not cause shortage of electrolyte due to the high ability of the claimed film to hold electrolyte. Furthermore, generally, there is a possibility that a film reduced in thickness may cause an instantaneous short circuit and an increased leaking current. Stacking the PAI in the claimed film can reduce defects, such as instantaneous short circuit and increased leaking current attributed to reduced thickness of the film.

(D) Excellent Resistance to Electrolyte and Oxidization.

In summary, the claimed composite porous film has significant superior results that an ordinary skilled in the art would not have readily expected.

Toyobo does not teach or suggest a composite porous film as recited in claim 9. For example, the Office Action acknowledges in page 3, line 12 that Toyobo Co. Ltd is “silent as to amide/imide bond ratio (recited in the instant claim 9).”

The Office Action then states that an ordinary skilled in the art at the time of the invention would have known that the amide/imide bond ratio in a polyamide imide resin affects the moisture stability, cost, dielectric constants and water stability, as evidenced in paragraphs [0054] and [0072] of Deshpande. Office Action, page 6, lines 13-21.

First, the present invention relates to a porous film for a lithium ion secondary cell and does not adjust an amide/imide ratio to improve moisture stability. A lithium ion secondary cell is a non-aqueous electrolytic secondary cell and does not use water. Therefore, the moisture stability of the film is irrelevant.

With regard to dielectric constant, Deshpande discloses that polyimide/polyamides, “like polyimides, have low dielectric constants.” Deshpande is silent on whether or how the dielectric constant may be affected the amide/imide ratio. Furthermore, when the polyamide-imide film is used for a separator for a cell, as described in the present invention, whether it has a high or low dielectric constant does not affect the performance of the cell. An ordinary skilled in the art would not have adjusted the amide/imide ratio in view of dielectric constant.

The Office Action also states in page 6, line 16 that “Deshpande discloses that polyimide has a higher cost as compared to polyamideimides.” However, Deshpande does not teach or suggest adjusting the amide/imide ratio to be from 10/90 to 45/55, as recited in claim 9, to reduce cost.

In summary, Toyobo and Deshpande do not teach or suggest a composite porous film with an amide bond/imide bond ratio of 10/90 to 45/55. On the other hand, Applicants have found surprisingly that an amide bond/imide bond ratio of from 10/90 to 45/55, as recited in claim 9, achieved unexpected superior results in terms of solvent solubility, the uniformity of the film, and prevention of deterioration of the electrolytic resistance. See page 5, lines 18-20 of the specification.

Furthermore, Toyobo discloses a porous membrane for blood purification, which is generally contemplated to separate a substance of a low molecular weight. The claimed film is used as a separator for a non-aqueous electrolytic secondary cell to keep positive and negative electrodes out of contact. One of ordinary skill in the art would not have been motivated to apply the film of Toyobo to a non-analogous art, such as a battery cell.

For at least the forgoing reasons, claims 1, 9-12, 18, and 19 would not have been obvious over Toyobo Co. Ltd (JP 07100201). Withdrawal of the rejections is respectfully requested.

II. Rejections of claims 1, 9, 13, and 14 under 35 U.S.C. 103(a)

Applicants respectfully traverse the obviousness rejections of claims 1, 9, 13, and 14 under 35 U.S.C. 103(a) over Shinohara et al (US 2002/0055036) in view of Toyobo (JP 07100201), with evidentiary support from Deshpande (US 2003/0215644).

Claim 9 recites a composite film comprising a polyamide-imide film that has an inherent viscosity of 0.5 dl/g or higher and an amide bond/imide bond ratio of from 10/90 to 45/55. Richer in imide than normal polyamide-imide, the claimed film has significant superior properties as described above.

Shinohara, as the Office Action acknowledges, does not disclose specific polyamide imide materials. The Office Action then states that one of ordinary skill in the art would have used the polyamide imide composition of Toyobo Co.

Ltd in the separator membrane of Shinohara to obtain a porous, heat-resistant, polyamide imide film. But as discussed above, Toyobo is a non-analogous art. One of ordinary skill in the art would not have been motivated to modify the battery separator membrane of Shinohara by using the membrane for blood purification disclosed in Toyobo.

Deshpande describes a polyamide-imide soluble in water. As the polyamide-imide is soluble in water, an ordinary skilled in the art would understand that it has a small molecular weight. In contrast, the present polyamide-imide has an inherent viscosity of 0.5 dl/g or higher, requires a molecular weight allowing a film to be formed, and does not have a property allowing it to dissolve in water.

Furthermore, Shinohara, Toyobo, and Deshpande fail to teach or suggest an amide bond/imide bond ratio of from 10/90 to 45/55, as recited in claim 9. As discussed above, an ordinary skilled in the art would not have been motivated to adjust the amide bond/imide bond ratio to fall within the range specified in claim 9. The Office Action states that an ordinary skilled in the art referring to Shinohara would also search for other documents to find a useful polyamide-imide resin (page 4, lines 19-21). However, a polyamide-imide resin is classified as a heat resistant resin. None of the cited references teaches or suggests adopting, among a wide variety of types of polyamide-imide resins, a particular structure and a particular amide/imide ratio that claim 9 recites.

For at least the forgoing reasons, claims 1, 9, 13 and 14 would not have been obvious over Shinohara et al (US 2002/0055036) in view of Toyobo (JP 07100201). Withdrawal of the rejections is respectfully requested.

CONCLUSION

The Examiner is encouraged to contact the undersigned regarding any questions concerning this amendment. In the event that the filing of this paper is deemed not timely, applicants petition for an appropriate extension of time. The Commissioner is authorized to debit Deposit Account No. 11-0600 the petition fee and any other fees that may be required in relation to this paper.

Respectfully submitted,

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Enclosures

1. Reference Fig. 1 and Reference Fig. 2
2. English Translation of Reference Fig. 2